National Aeronautics and Space Administration

NASA Case Study GSFC-1011C-1

THE *CALIPSO* MISSION
Project Management in the "PI Mode": Who's in Charge?

The *CALIPSO* mission was proposed in 1998 as a pioneering tool for measuring clouds and tiny airborne particles known as aerosols. Carrying the first lidar (light detection and ranging) polarization instrument into orbit, *CALIPSO* (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) would enable scientists to build 3-D models of Earth's atmosphere and gain a better understanding of the planet's climate system. Among other uses, the models could be applied to pollution control and weather forecasting. (See **Figure 1**.)

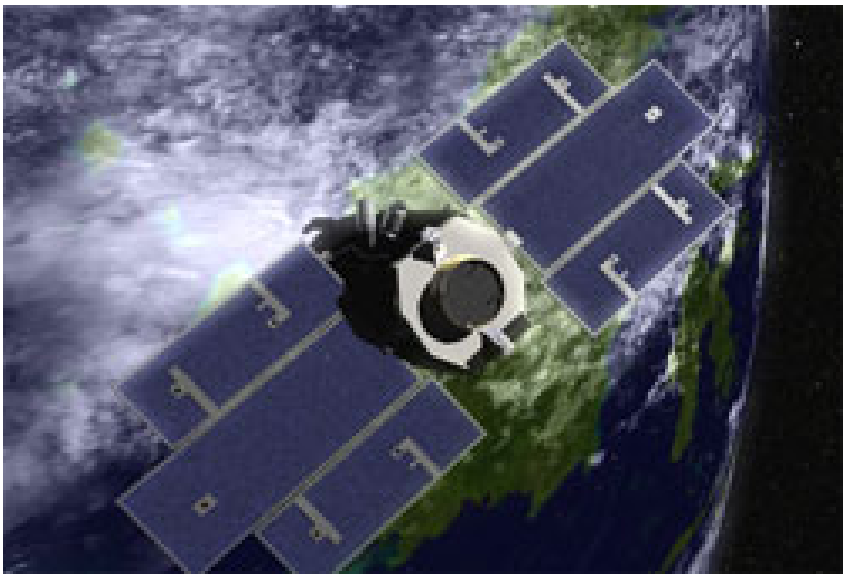

Figure 1. CALIPSO/CloudSat observing Earth's atmosphere. NASA image

By the spring of 2003, however, the mission was facing a host of technical and organizational problems, the project manager had recently retired, and cancellation was not out of the question. Development of *CALIPSO*—a joint mission between NASA and the French space agency Centre National d'Etudes Spatiales (CNES)—had been hampered for years by a complex organizational structure and a

difficult management relationship between Langley Research Center (LaRC), which was the NASA center managing the project, and Goddard Space Flight Center (GSFC), which had oversight responsibility for the mission. Communication issues, management turnover, the International Trafficking in Arms Regulation (ITAR), and instrument and spacecraft problems had all presented obstacles. Now the challenges had converged to push back the project schedule, drive up costs, and threaten the viability of the mission.

Origins of *CALIPSO*

Originally named *Picasso*, *CALIPSO* was proposed by LaRC for NASA's second series of missions in the Earth System Science Pathfinder (ESSP) program. *CALIPSO's* proposed lidar instrument was the maturation of an experiment called LITE (Lidar In-space Technology Experiment) developed in the early 1990s by LaRC and carried in the payload bay of *Space Shuttle Discovery* in 1994.

CALIPSO was the only outright selection from the proposals received in the ESSP announcement of opportunity (AO). *CloudSat*, whose radar measurements would complement *CALIPSO's* lidar observations, was the other eventual winner from the AO, chosen after a follow-up study and downselect. Once *CloudSat* was selected, the two missions agreed to formation-fly with the Aqua mission of the Earth Observing System (EOS). They would be co-manifested on a single *Delta II* launch vehicle.

With *CALIPSO* as the vanguard of the next generation of Earth-science space missions, expectations ran high. "For the first time," said Ghassem Asrar, NASA's Associate Administrator for Earth Science, "we will be able to construct three-dimensional structures of the atmosphere to better understand the role of clouds and aerosols in Earth's climate."

The PI Mode of Management

When *CALIPSO* originated, NASA was in the early stages of the principal investigator (PI) mode of project management, an approach advocated by NASA Administrator Dan Goldin. (*CALIPSO* was also conceived in the "FBC"—faster, better, cheaper—era.) The premise was that PIs chosen to lead future space-science missions would have complete responsibility for the mission, with minimum project guidance or involvement from NASA.

There were two schools of thought about that. One held that the PI mode would lead to increased competition among NASA centers, ultimately benefiting the agency. Specifically, in that view, the PI approach would develop project management capabilities outside Goddard and the Jet Propulsion Laboratory (JPL), where most of the agency's robotic space-flight missions were centered. The other camp argued that flight missions should only be done by Goddard and JPL, because it was simply too costly to replicate project management capabilities elsewhere.

Though *CALIPSO* had been proposed by Langley and the PI was at Langley, the project was funded through the ESSP program office at Goddard (like all other ESSP missions in the program). Based on the emerging PI mode of management, however, the program office was expected to apply only "light touch" oversight to the *CALIPSO* mission, allowing the PI team to manage it. This was in accordance with the AO:

> The Principal Investigator and mission team will have full responsibility for all aspects of the mission, including instrument and spacecraft definition, development, integration, and test; launch services (if acquired by the mission team) or mission launch interfaces (if launch service is NASA-provided); ground system; science operations; mission operations; and data processing and distribution….
>
> It is the intent of NASA to give the PI and the mission team the ability to use their own processes, procedures, and methods to the fullest extent possible.

Project Organization Structure

Roles/Responsibilities: GSFC/LaRC Divide

Notwithstanding the announcement of opportunity, the centers running *CALIPSO* took different positions on the responsibility for project management. The Langley director was interested in his center gaining capability for full flight-mission project management. Further, as funding for aeronautics was going down, LaRC envisioned Earth science as a growing piece in its budget pie. The director wanted to bypass the program office at GSFC and report directly to NASA Headquarters (HQ), and requested this many times. His logic was that LaRC deserved the chance to prove itself in flight project management just as it had over the years for flight instrument management.

The GSFC director took the position that Goddard had proven management capability for the flight missions *CALIPSO* required; in support of that view was the fact that LaRC had not managed a full flight mission since the *Viking* mission to Mars in the 1970s.

HQ defined and confirmed the roles and responsibilities as follows: Langley would serve as mission office, responsible for the development of the primary science instrument, while Goddard would provide high-level technical and programmatic oversight—again, with a light touch—through the ESSP program office and in its role as the lead center.

Mission Partners

The project structure was not restricted to NASA or the United States. *CALIPSO* was a partnership with CNES with a co-principal investigator from Simon Laplace Institution (the French research organization). Through the NASA–CNES memorandum of understanding (MOU), CNES was responsible for providing a number of components and services, including the ground stations, mission operations, and tracking as well as assembly, and the integration and test of the payload onto the spacecraft bus. In addition, the agency was responsible for one of the three science instruments, the imaging infrared radiometer, to be built by the French firm *Sodern*, and providing the *Proteus* spacecraft bus, to be built by Alcatel of France. (See **Figure 2** for a diagram of the project organizational structure.)

Also on the team was Ball Aerospace & Technologies Corp. (BATC). Together with Langley, BATC was responsible for designing and building the CALIOP lidar (Cloud-Aerosol Lidar with Orthogonal Polarization), the main instrument on the satellite (see **Figure 3**). In addition, Ball was contracted to deliver a wide-field camera, the third instrument in the payload. The BATC facility in Boulder, Colorado, would serve as the location for integration of the three instruments.

BATC was also responsible for delivering all ground equipment to test, calibrate, and install the payload onto the spacecraft bus. It would also support LaRC in the interface definition between the payload and the bus, and support the installation of the payload onto the spacecraft at the *Alcatel* facilities in Cannes, France.

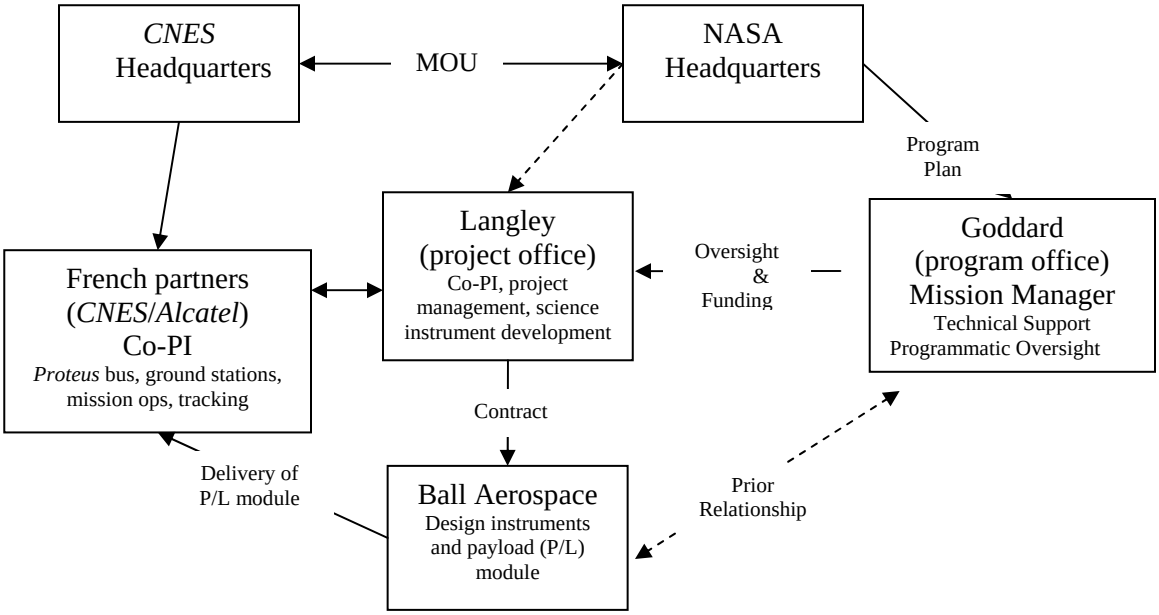

Figure 2. Organizational relationships of the CALIPSO mission.

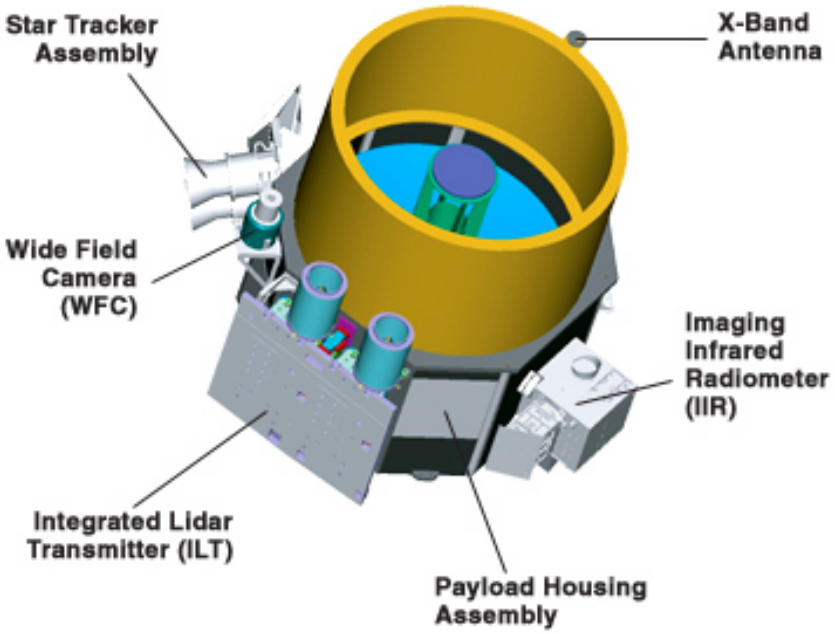

Figure 3. The CALIPSO payload: lidar telescope with infrared radiometer and wide-field camera. NASA image

Mission Management

Prior to *CALIPSO*, LaRC had partnered successfully with program-office mission managers at other locations, including NASA HQ and Johnson Space Center, as well as at GSFC (the CERES [Clouds and the Earth's Radiant Energy System] instrument had been developed at LaRC and flown on the Goddard-led Terra and Aqua missions). LaRC had also engaged successfully with Russian, French, and Italian firms in cooperative endeavors for instrument deliveries.

During the early phases of *CALIPSO*, implementation proceeded along relatively normal lines, and Goddard followed the light approach to oversight. The mission manager (MM) was located at GSFC and reported to the program office there, while interfacing with the project office at LaRC and serving as the conduit for technical support, as requested by Langley. This approach was consistent with other missions in which LaRC had been responsible for delivering instruments to Goddard-managed contractors. Still, questions about the management organization persisted among the LaRC team:

1. If the *CALIPSO* project was centered at LaRC and reported to the program office at GSFC, why was the project manager reporting to the MM instead of directly to the program manager?
2. If the MM was to be part of the project team, as the program manager had said, why wasn't he located at Langley?
3. In fact, why have a MM at all, if the MM's only function was to act as a link between the program manager and the project manager?
4. Under the PI mode, wasn't the PI supposed to run the mission? What did the original AO mean when one center has program responsibility and another has project responsibility?

Members of the Goddard team also had questions:

1. How could they be expected to be responsible for mission management if they did not have authority to manage the overall schedule (and had little if any confidence in LaRC's schedule)?
2. How could they provide oversight when they didn't know what all the partners and contractors were doing?
3. What was the overall responsibility split between the program office at GSFC and the project office at LaRC? What exactly was the role of the lead center?
4. Who was HQ holding accountable for mission success? Why wouldn't HQ clarify roles and responsibilities?

While concerns mounted, other issues were cropping up; for example, the Langley team was having a hard time getting the contract with BATC in place. Then, in the spring of 1999, the associate administrator for Earth science issued a directive that lead centers should take responsibility for running mission readiness reviews (MRR) and certifying flight readiness. In that light, the GSFC director felt it was even more necessary for Goddard personnel to be directly involved in *CALIPSO*—essentially, to have more oversight—if they were going to be held accountable for the outcome. Now it appeared that Langley and Goddard were equally responsible for the *CALIPSO* mission.

Mistrust and Misunderstanding

To gain confidence in the technical approaches LaRC was taking on the project after HQ issued the new directive, an increasingly large "shadow team" at GSFC began to mirror Langley's work. Predictably, the feeling at LaRC was, "they don't trust us." At Goddard, there was a sense among some managers that Langley was keeping them in the dark. Within Langley too, some team members felt they didn't have the complete support of upper management and wondered whether certain senior managers really wanted to get into mission management at all.[1]

At the technical level, problems were flaring up with both the lidar at BATC and with the spacecraft. It was known from the beginning that the CALIOP instrument would be a challenge. LaRC, however, felt that its experience on the LITE project and its joint effort with BATC/Fibertek developing and testing the risk reduction laser (RRL) more than adequately addressed Goddard's concerns. For its part, GSFC, still stinging from problems with the Vegetation Canopy Lidar (VCL) and laser development issues on the ICESat mission, was much more critical of the instrument development on *CALIPSO*.

To make things worse, BATC was in the awkward position of having communication paths and relationships—and loyalties—with both LaRC and GSFC, a situation that often made feedback and prioritization difficult and inconsistent. For BATC, and for CNES, the mixed signals emanating from the two NASA centers were confusing: Who was really in charge?

Meanwhile, the U.S. International Trafficking in Arms Regulation (ITAR) was making the interfaces with the French partner very difficult. Under ITAR restrictions, LaRC was finding it hard to share information with the CNES/Alcatel team, and at times CNES/Alcatel representatives were required to leave project meetings when ITAR-sensitive material was discussed. The French were alternately frustrated and insulted. As a result, CNES sometimes refused to provide reciprocal information when requested. Language barriers presented other issues that afflicted the relationship.

At Alcatel, spacecraft issues had caused the Preliminary Design Review (PDR) to be pushed back until July 2000. This, in turn, had delayed the combined mission PDR/MDR (Mission Definition Review) from April 2000 to September 2000. More than a year and a half after *CALIPSO* had been chosen as the only direct selection in the second ESSP mission series—heralding a new era of Earth science discoveries from space—the project leaders found themselves on the defensive, as the PDR/MDR approached.

Fractious Reviews: Bad Feelings

The MDR panel was made up of experienced senior project managers and engineers, mostly from GSFC (or retired GSFC personnel), with one independent consultant. The reviews, held over the course of five days, did not go well. The panel focused on what it saw as a lack of demonstrated management at LaRC, especially in laying the proper groundwork with CNES and interfacing with the French agency.

[1] Despite frustration with the way the program was being managed, the LaRC and GSFC teams maintained good working relationships, according to members of both teams, and personnel at both centers put much of the blame on NASA Headquarters.

LaRC was heavily criticized on cost and schedule management issues. And with BATC presenting the bulk of the project material, the panel was given the negative impression that Langley was not in control of its contractor.

Overall, the GSFC reviewers embraced the notion that LaRC suffered from inexperience with end-to-end flight systems. While the LaRC team felt abused by the review process led by Goddard personnel; GSFC, feeling responsible for the mission, was worried not only about the outcome of the project but about the Center's reputation.

Two months after the contentious preliminary reviews came the Mission Confirmation Review (MCR) at HQ, to determine if the project was ready to proceed from the formulation stage to full implementation. Based on the PDR/MDR, the outlook was not bright. By now, serious reservations had surfaced concerning the project plan and implementation. Aware of the concerns raised about project viability, HQ delayed the confirmation approval for several months until the spring of 2001. Even after a successful confirmation review, cost and schedule issues dogged the project for the next two to three years, with the threat of project termination periodically rearing it head. (See **Exhibit 1** for a timeline.)

Management Upheaval

CALIPSO struggled forward, driven by the force of a determined and dedicated project team. Periodic attempts to forge a new, more effective management relationship for the good of the mission resulted in still more changes in project/program personnel at both LaRC and GSFC. In mid-2002, a new mission manager was assigned at Goddard, and the project saw changes in the management ranks at both centers.

By that time, there was an unavoidable sense that a "replan" was needed for *CALIPSO*. The program and project launch readiness schedules differed by about a year. Technical glitches and failures in the instrumentation had occurred. There was friction between all parties. Then, in the spring of 2003, still more change: The project manager at Langley retired, which left a leadership void.

Decisions: Crisis… or Opportunity?

It is spring of 2003. You are in the role of management decision-maker on *CALIPSO*. The associate administrator for ESSP has called a meeting with the directors of Langley and Goddard to try to find a way forward for the project. Your center director has asked you to provide recommendations, prior to the meeting, for getting *CALIPSO* back on track

You ponder the state of the mission. Despite the problems so far, is it possible that the management situation presents an opportunity? Could Langley and GSFC stake out some common ground to find a "one NASA" solution—and get *CALIPSO* off the ground?

Formulate your recommendations to the director (pick either LaRC or GSFC) and discuss your ideas with your team, considering the:

- **Problems related to authority, roles, and responsibility**. What are some possibilities for resolving the issue of dual responsibility between LaRC and GSFC and getting the right project manager on board? What kind of project manager is needed at this time?
- **Interfaces between GSFC, CNES/*Alcatel*, BATC, and LaRC**. The partner relationships are interfering with the technical focus, as the French partners do not understand Goddard's role and rarely interact with the GSFC team. At the same time, the LaRC team feels GSFC regards both Langley and CNES as contractors instead of partners. Are these cultural or management issues, or both? How can those issues be addressed?
- ***CALIPSO* mission needs a completely new direction**. Should the viability of the mission itself be reconsidered?
- **PI mode of project management**. Are there lessons for other PI missions?

Exhibit 1

CALIPSO Mission Development Timeline
(Through Spring 2003)

Event	Date
Mission selection (originally called Picasso)	December 22, 1998
Picasso kick-off meeting at GSFC	January 25, 1999
Associate administrator for Earth science directive: All lead centers to use Program Management Councils to run mission readiness reviews for flight missions, certify flight readiness	March 1999
Picasso project kick-off meeting at LaRC	April 19–23, 1999
CloudSat co-manifested	May 1999
LaRC/Ball contract signed	August 10, 1999
Systems Requirements Review (SRR)	January 2000
Proteus spacecraft Preliminary Design Review (PDR) at *Alcatel*	July 2000
PDR/MDR	September 18–22, 2000
Mission Confirmation Review (MCR) (confirmation delayed)	November 15, 2000
Delta MDR	March 2001
Delta Confirmation Review (program/project approval)	April 2001
Critical Design Review (CDR) (also called Mission CDR)	March 18–22, 2002
Delta MCDR	September 2002
New program manager assigned at GSFC	November 2002
Project manager retires from project and LaRC	March 2003
New program executive assigned at HQ	March 2003
Spacecraft CDR in France	April 2003